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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	
First Inventor or Application Identifier	60/120,639
Title	BI-DIRECTIONAL SWITCHED RF....
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231**

1. [✓] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [✓] Specification [*Total Pages* 43] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - ~~Reference to Microfiche Appendix~~
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [✓] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 9]
4. Oath or Declaration [*Total Pages* 52]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

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5. [ ] Microfiche Computer Program *(Appendix)*
6. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
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ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [ ] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
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[X] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: 60/120,639

Prior application information: Examiner ______ *Group / Art Unit:* ______

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17. CORRESPONDENCE ADDRESS

[ ] *Customer Number or Bar Code Label* *(Insert Customer No. or Attach bar code label here)* or [X] *Correspondence address below*

Name	MICHAEL F. YOUNG				
Address	7110 SEA CLIFF RD				
City	McLEAN	State	VA	Zip Code	22101
Country	USA	Telephone	703-237-9090	Fax	703-237-9092

Name *(Print/Type)*	MICHAEL F. YOUNG	Registration No. *(Attorney/Agent)*	
Signature	MFY	Date	2/14/2000

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STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(b))--INDEPENDENT INVENTOR

Docket Number (Optional)

Applicant, Patentee, or Identifier: MICHAEL F YOUNG

Application or Patent No.: 60/120,639

Filed or Issued: 02/18/1999

Title: BI-DIRECTIONAL SWITCHED RF AMPLIFIER, ...

As a below named inventor, I hereby state that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in:

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YOUNG DESIGN, INC
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Separate statements are required from each named person, concern, or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

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MICHAEL F YOUNG	HUNTER JONES	JOHN CASAER
NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
MFY	HJ	John Casaer
Signature of inventor	Signature of inventor	Signature of inventor
02/14/00	02/14/2000	02/14/2000
Date	Date	Date

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STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(b))--INDEPENDENT INVENTOR	Docket Number (Optional)

Applicant, Patentee, or Identifier: MICHAEL F YOUNG

Application or Patent No.: 60/120,639

Filed or Issued: 02/18/1999

Title: BI-DIRECTIONAL SWITCHED RF AMPLIFIER, ...

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PAUL AKIMOV		
NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
Paul Akimov		
Signature of inventor	Signature of inventor	Signature of inventor
02/14/2000		
Date	Date	Date

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR PATENT

BI-DIRECTIONAL SWITCHED RF AMPLIFIER, WATERPROOF HOUSING, ELECTROSTATIC OVERVOLTAGE PROTECTION DEVICE, AND MOUNTING BRACKET THEREFOR

Inventors: Michael F. Young, Hunter Jones, John Casaer, and Paul Akimov

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Conversion of Provisional Application Ser. No. 60/120,639, filed February 18, 1999.

BACKGROUND OF THE INVENTION

The present invention is a result of the proliferation of low power, Spread Spectrum radio modem devices in the 902-928 MHz, 2.4 GHz and 5.7 GHz bands. Popularity of these radio devices is largely due to FCC regulations that allow appropriately certified radio transceivers to be operated license free. This certification requirement restricts the transmitter output power in order to enable many users to share the band. Further, since the radios are Spread Spectrum devices, they can generally tolerate interference from other radios transmitting in the same geographical area.

Many of these prior art devices were designed and intended for short range operation (less than 1000 feet, for example, due to the low transmit power restrictions and the requirement of unobstructed line-of-site between antennas for maximum range). However, if external outdoor gain antennas are placed on tall buildings or radio towers, considerable line-of-site ranges (measured in miles) are possible. The problem here is that the losses in the typical, inexpensive coaxial

transmission line between the radio and the antenna at these frequencies can be excessive unless prohibitively expensive cable is used. Putting an antenna on a tall radio tower or building would give clear line of sight to many locations, but this is largely defeated by the transmission cable loss.

In a typical RF bi-directional amplifier application, a duplex amplifier with heavy filtering, such as in U. S. Patent 5,502,715 to Penny, is used. However, this is in general unsatisfactory due to the fact that not only are both transmit and receive amplifiers are on at all times, thus leading to wasteful power usage, but also heavy filtering is also necessary to keep the transmit and receive signals from interfering with each other, leading to further expense and power wastage. Still further, since each transmit and receive signal must be put to a separate frequency to avoid interference, this design is wasteful of spectrum bandwidth, a scarce commodity in many applications.

SUMMARY OF THE INVENTION

It is an object of the invention disclosed herein to overcome these problems and provide a telecommunications system for ranges up to 60 miles point-to-point while keeping the radiated power compliant with the certification regulations.

It is also an object of the invention to provide an improved arrangement for amplification of transmit and receive radio signals. More specifically, the invention discloses the means to locate a half-duplex, switching bi-directional amplifier close to the antenna.

It is also an object of the invention to provide such an RF amplifier with an improved waterproof housing enclosure for protection against water accumulation.

It is still further an object of the invention to provide a universal mounting V bolt mounting bracket for the waterproof housing enclosure.

It is still further an object of the invention to provide for an improved mounting arrangement for the internal printed circuit boards directly to

the housing cover to provide for minimum VSWR from the coaxial connectors to the PC board strip line traces.

It is still further an object of the invention to provide temperature compensated RF level sensing circuitry to permit reliable operation over a very wide temperature range.

It is still further an object of the invention to provide LED indicators on the DC injector circuitry to show the operational status of the remote bi-directional switching amplifier by monitoring the current drawn by this remote bi-directional switching amplifier.

It is still a further object of the invention to provide a solid state switch for switching between the transmit (TX) and the receive (RX) modes of the remote bi-directional switching amplifier.

It is still a further object of the invention to provide for an electrostatic overvoltage discharge protection device, in one embodiment at the antenna port in the remote bi-directional switched amplifier circuit board, and in another embodiment as a separate component for generalized radio frequency use.

Additional objects, features, and advantages of the various aspects of the present invention will become apparent from the following description of the preferred embodiments, which description should be taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a typical installation diagram with the bi-directional switching amplifier in conjunction with the related elements for a telecommunications system.

Figure 2 shows how the DC power is inserted into the transmission line to the remote mounted amplifier module through the DC injector circuitry.

Figure 3 shows the functional block diagram of the bi-directional switching amplifier module.

Figure 4A shows the details of the preferred electrostatic overvoltage discharge protection device used in a circuit board

environment such as at the antenna connector on the bi-directional switching amplifier module.

Figure 4B shows the details of the preferred electrostatic overvoltage discharge protection device in a separate component form.

Figure 5 shows the details of a preferred RF sensing circuit used in the remote bi-directional switching amplifier to enable it to switch from the receive to the transmit mode of operation.

Figures 6A and 6B show the PC board mounted on the housing cover of the bi-directional switching amplifier module or of the DC injector in isometric and side view, respectively.

Figure 7 show an isometric view of a preferred bi-directional switching amplifier housing mounting arrangement.

Figures 8A, 8B, and 8C show various views of a preferred universal mounting L-member.

Figures 9A, 9B, and 9C show various views of a preferred implementation of the universal channel bracket to hold the L-bracket against the mounting mast.

Figure 9D shows a preferred implementation of the V-bolt used with the universal channel bracket to hold the L-bracket against the mounting mast.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 show the remote bi-directional switching amplifier telecommunications system in a preferred typical installation. The bi-directional amplifier **1,** inside the housing enclosure **94**; the DC power input to the housing enclosure **94** from the DC power injector **2** supplied through connection **20**, connection between the bi-directional switching amplifier **1** at **29** to the antenna **87** is made through a short length of inexpensive connecting cable **3** and the L-bracket **93** in conjunction with the mast **92** are the primary preferred components of the remote part of the system. The secondary components include a transmission line **4** connected to the housing enclosure **94** at **20**, a DC Power Injector **2** preferably located remote from the bi-directional switching amplifier **1** housing **94**, a DC Power Supply **5** which can be either DC or AC line

operated, a radio transceiver **6**, an appropriate computer, router or terminal device **7**, and connecting cables between the various elements, such as **9** between the DC power injector and the radio transceiver. The connecting cables can be varied in type so long as they are compatible with the system. The object of the invention is to use inexpensive, easily available cables wherever possible.

The bi-directional switching amplifier **1** is mounted physically close to the antenna and is preferably, but not necessarily, outdoors. It boosts the low power transmit, TX, signal from the radio transceiver **6** to provide the full transmit output power right at the antenna *per se.* It also contains a low noise amplifier (LNA) to pre-amplify the received signal when in receive mode, RX, which overcomes the loss in transmission line **4** to the radio transceiver **6**. The bi-directional switching amplifier module **1** has an RF (radio frequency) sensing circuit to automatically switch from the receive RX mode to the transmit TX mode when the transceiver radio **6** goes into transmit, TX. The details of this bi-directional switching amplifier **1** are shown in Figure 3 and described in detail below.

The DC power injector **2** passes the RF signal through it transparently, and injects a DC voltage onto the transmission line **4** to provide DC power to the remotely mounted bi-directional switching amplifier **1** in lousing **94**. The DC power injector **2**, as at Figure 2, has LEDs to indicate when the externally mounted remote bi-directional switching amplifier is in receive, RX, or transmit, TX, modes for operator monitoring.

One of the preferred features of the invention is the bi-directional switching amplifier module **1** in housing **94** mounting arrangement and hardware associated with it. This mounting arrangement ensures that the bi-directional switching amplifier housing enclosure **94** is installed with the coax connectors **64** mounted to the cover **62** are facing in a downward direction. This mounting arrangement prevents water accumulation and migration into the housing enclosure **94**. This mounting arrangement, in one embodiment, preferably also features a special design "V" bolt **90** that enables the preferred L-bracket **93** in conjunction with the preferred universal channel bracket **91** to be mounted on pole or mast **92** with diameters from ½ " to over 3", thus

providing for a universal mounting. This completed preferred mounting arrangement is shown at Figure 7. A specific drawing for each piece is shown at Figures 8A to 9D.

The DC Power Injector

Referring again to Figure 2, the DC power injector **2** gets DC power from the DC power source **5** through connector **67** and inserts the DC current to the hot lead **72** of the coax connector that connects to the transmission cable through power resistor **66** and choke **63** in order to power the bi-directional switching amplifier electronics. LED indicators **70**, **71** are provided to show to the operator that DC power is applied and when the bi-directional switching amplifier module **1** switches into the transmit mode, TX. The DC power injector **2** also provides the necessary DC blocking to radio transceiver **6** through connector **60** with capacitor **61**.

As seen by refering to the figures, the radio transceiver **6** is connected to the DC power injector **2** via a coax cable **9** at the input

connector **60**, **64** preferably to a 50-ohm stripline **63** on the PC board **61**,. The RF signal to and from the radio transceiver **6** is coupled to the output connector **72** via a blocking capacitor **61** which keeps the DC voltage from going into the radio transceiver **6**. DC voltage is injected onto the bi-directional switching amplifier side of this coupling capacitor **61** from a jack or plug **67** through an RF choke **63** and a power resistor **66**.

The DC voltage drop across the power resistor **66** is a measure of the current drawn by bi-directional switching amplifier **1** module. Differential voltage comparator circuitry **68** compares this voltage drop to a predetermined level. If the current is less then this predetermined level, the comparator circuitry **68** illuminates the green Receive (RX) LED **71**. If the current is greater then this predetermined level, the comparator circuitry **68** illuminates the red Transmit (TX) LED **70**.

The Bi-directional Switched Amplifier Module

The bi-directional switched amplifier module **1** circuitry is housed in a watertight enclosure housing **94** physically mounted adjacent to the antenna **87**. Hereinafter, the terms "enclosure" and "housing" will be used interchangeably. As shown in Figure 3, the bi-directional switched amplifier **1** gets its DC power from the coax transmission line **4** connected to it at the input coax connector **20**. The DC power is siphoned off and the RF signal is capacitively coupled to the RF radio transceiver switch **21**. Normally the bi-directional switching amplifier **1** is in the Receive (RX) mode as Figure 3 illustrates. In this mode, RF signals from the antenna port connection **29** are passed through the RF antenna switch **22**, through the optional bandpass filter **27** and amplified by the RX LNA **26**. To reduce the signal and noise coming out of the amplifier, an optional attenuator pad **31** can be installed.

When the radio transceiver **6** connected to the DC injector **2** goes into the transmit mode, the TX power is detected by the sense circuitry

24 and switches both the switch **21** from the radio transceiver and the switch **22** to the antenna to the TX position. The power sense circuitry **24** also applies DC power to the transmitter power amplifier **25** and removes power from the RX LNA **26**. In this mode, the RF signal from the radio transceiver **6** can be passed through the optional RF attenuator pad **23**, into the transmitter TX power amplifier **25** and to the antenna port **29** via the antenna RF antenna switch **22**. When the radio drops out of transmit, the TX power sense circuitry switches the RF switches **21**, **22** back to the receive RX mode, removes power from the transmitter power amplifier **25** and turns the receive RX LNA **26** back on.

ELECTROSTATIC OVERVOLTAGE PROTECTION DEVICE

Another aspect of the invention is an improved electrostatic overvoltage protection device, or “lightning arrester.” Here it has been discovered that a conductor of one-quarter the desired wavelength of a predetermined frequency band connected between a source of signal and a reference potential, such as ground, will have almost no effect on

the desired signal band and signal transmission but will shunt virtually all frequencies outside this predetermined frequency band to a reference potential such as ground, thus protecting the integrity of any electronic component connected to the signal input.

In a first preferred embodiment, the electrostatic overvoltage protection for an electronic circuit in a circuit board environment, such as the bi-directional switching amplifier, is shown in Figure 4A. This protector can protect against lightning, electrostatic charge from the environment, an Electro Magnetic Pulse ("EMP"), and any other source of static or transient overvoltage. The coax connector **29** that connects to the antenna in a preferred embodiment has a loop of heavy gauge conductor **91** of a length equal to one-quarter of the wavelength of the desired RF operational band connected from the signal input **92** of connector **29** to a source of reference potential, such as ground 93 on the PC board, thus forming an RF choke to that desired frequency band at the input and a direct ground to all other frequencies. This conductor **91** may also be a trace on the PC board or any other convenient means of forming an equivalent one-quarter wavelength conductor such that it

shorts the center pin **92** directly to a reference potential such as ground **93** on the PC board for all frequencies outside the desired frequency band. This RF shunt choke is has a negligible effect on the desired RF band signal passing through the amplifier. However, any stray DC, lightning, or other electrostatic overvoltage fault at the input pin **92** of the antenna connector **29** finds this loop a very low impedance to ground (provided that the mast or pole is properly grounded) and shunts the current through it to this ground, thereby protecting the electronic circuit board, such as the bi-directional switching amplifier 1.

A second embodiment of the electrostatic overvoltage protection device is in a separate component form with both the internal and external details are shown at Figure 4B. The protection device, or arrester, is constructed of a T-connector housing **100** with input connection **101** and output connection **102**. The input **101** and output **102** are bi-directional and may be interchanged. A pass-through conductor **103** connects the input **101** and output **102**, and conductor **103** is surrounded by a suitable dielectric material **112** which is inside of the body housing **100**. The dielectric material **112** may also be air or a

material such as rexolite, delrin, teflon or other non-conductor suitable for the radio frequency band intended. The dielectric material **112** may be a combination of air and other non-conducting materials.

Here the one-quarter wavelength protector of the desired frequency band, taking into account the dielectric constant of the dielectric material **112**, is conductor **104** which connects to the through conductor **103** at one end, and to a grounding or shorting member to the outside housing at the other end. One manner of achieving this shorting to the outside T-connector housing **100** is shown here through a ground pin such as **105** on the ground end. Here the ground pin **105** extends through an end cap **106** and thus forms an effective short to the external protector housing **100** for the conductor **104**. The connector-protection device **100** can then be put to a source of reference potential such as ground by any convenient manner. In one preferred embodiment, the ground pin **105** extends beyond the housing **100** to form a suitable ground screw **110**. As above, the total length of the conductor **104** and ground pin **105** is one quarter wavelength, $\lambda/4$, length **108** (or any odd multiple of one quarter wavelength) of the desired operating frequency as measured from the

pass-through conductor **103** to the end cap assembly **106.** As above, this presents a short circuit to direct currents (DC) and any non-desired frequency and a high impedance only to the desired operating frequency band. The assembly of conductor **104**, ground pin **105**, end cap **106**, and ground screw **110** may be constructed as one continuous piece, if desired.

The end cap **106** can attach to the main body of the arrester **100** by either an internal or external thread **107** (male or female connection) or any other suitable means of connection. In one simple preferred embodiment the ground screw **110** which passes through the end cap **106** is used for the attachment of a grounding conductor **111**, which can be a combination lug and/or braid, and held in place by nut **109**. The ground screw **110** may be of any length and is preferably highly conductive. Washers or other appropriate mounting hardware may be used between conductor **111**, end cap **106** and nut **109**. Ground conductor **111** may also be attached to end cap **106** by soldering, riveting, welding or any other method.

Still further, the shorting of conductor **104** to the housing **100** at the ground end can be done by any other convenient means such as a copper foil, a highly conductive plate soldered, brazed, or welded in place, or any other conductor connection between the distal end of conductor **104** and the housing **100** in place of this end cap **106**, which is only one convenient manner of providing this connection, and a threaded member is not necessary, but useful in some situations to tune the desired band.

This separate component protection device of Figure 4B can have an entire range of other uses other than as an antenna protector, for instance such as protecting signals between computers or other communications devices, protection of control signals to power equipment, or any kind of networking where there may be some kind of electrostatic or transient overvoltage fault condition in a radio frequency path of a particular predetermined frequency band connection.

The RF Power Sense Circuitry

The RF Power Sense Circuitry **24** best seen in Figure 5, needs to detect low level RF signals and work in hostile outdoor environments. It is vital that the bi-directional switching amplifier module **1** quickly and reliably detect the presence of a transmitted signal from the radio transceiver **6** under all temperature ranges in order to switch from the Receive RX to the Transmit TX mode. The present invention utilizes a solid state circuit that senses and detects the presence of radio frequency energy (RF) and provides a digital output signal when said Transmit TX RF signal is present. The sensing circuitry **24** utilizes detection diodes **40**, **40'** that are forward biased to almost the point of conduction to provide for maximum sensitivity and reliable detection for signal levels as low as 1 milliwatt. The biasing circuitry for these diodes are temperature compensated with a temperature-controlled resistor (thermistor) **39** to ensure consistent performance over a wide temperature range.

Referring to Figure 5, RF energy from the bi-directional switching amplifier **1** input connector **20** is coupled via a capacitor **41** to the junction of the preferred low capacitance Schottky dual diodes **40, 40'** in series. While any suitable diodes can be used, these have been found to be cost effective, reliable components well suited for this application. These diodes **40**, **40'** combined with capacitors **42**, **45** form a voltage doubling circuit to rectify and detect an RF signal on the input connector **20**. The resulting rectified signal is applied to an input **58** of a comparator **53**.

To provide for maximum sensitivity, diodes **40, 40'** are forward biased to just below the conduction point via a 5 volt regulated source **59** through the biasing resistors **43**, **44**, and **46**. However, since the transconductance of the diodes **40**, **40'** change greatly with temperature, a thermistor **39** is added to the circuit. This thermistor **39** adjusts the current flow through the diodes **40**, **40'** to provide a relatively uniform RF signal level detection point over a very wide temperature range.

The trip point for the circuitry is set by the voltage reference source **50**. When the DC voltage present on input **58** exceeds the pre-set DC

level on input **57**, the comparator **53** changes state indicating that an RF signal is present at the input connector **20**. The output **56** of this comparator **53** goes low. A second comparator **55** inverts this signal and provides a complementary logical high output at **54** for use by the RF switching and other circuitry in the bi-directional switching amplifier module.

The Preferred Mounting Arrangement for the Bi-directional Amplifier Module

Waterproof enclosures, even if mounted properly, can ultimately have a water leak when mounted outdoors through the coaxial connectors that penetrate its surface. The present invention discloses a preferred arrangement to mount such a waterproof enclosure or housing **94** containing the bi-directional switching amplifier module 1 outdoors especially to a pole or mast **92** mounted physically close to the radio antenna **87**. The antenna **87** can be at any adjacent position to the enclosure housing **94**, i.e. above the enclosure, at the same height, or

below the enclosure. In the preferred embodiment, the mounting of the enclosure **94** for the bi-directional switching amplifier **1** has the connectors facing in a downward direction. Especially when used with drip loops, this mounting arrangement results in water being drawn away by gravity from the waterproof enclosure **94** and the external connections rather then giving it a direct path to enter such as would be the case if the connectors **20**, **29** were installed on any other face of the enclosure **94**. The connection to the antenna **87** is also preferred to be in a downward position to minimize water migration into the connecting cable **3**.

Further, conventional U-bolts mounting means or any other conventional structure for adjustably mounting the antenna **87** and housing **94** can be used with the invention. Conventional U-bolts and round masts **92** would be particularly useful in a new installation of many units where all the mounting means would be the same. However, in retrofit installations U-bolts only lend themselves to mountings on a very limited range of pole or mast diameters. Thus while U-bolts can be used with the invention, a preferred new and improved universal mounting means overcomes problems associated with these limitations by enabling

installers to use a wide range of masts or poles **92** to mount the waterproof enclosure **94** and antenna **87**. A new mounting bracket **93** and V-bolt design **90** such as described herein enables the amplifier enclosure **94** to be mounted on any diameter mast or pole **92** from ½" to over 3" diameter. Thus during field installations, and especially retro-fit installations, an installer would not have to locate a mast or pole of particular diameter to accommodate the limited range the diameter of standard U-bolts mounting arrangements, but could bolt the mounting hardware to just about anything in this universal arrangement.

This preferred universal mounting arrangement is shown in Figures 7, 8A-8C, and 9A-9D. It comprises the V-bolt **90**, a stepped channel piece 91 for the V-bolt and pole **92** to work against, L-bracket **93** to secure the channel piece **91** to the bi-directional switching amplifier module housing **94** and the nuts and washers **95** needed to hold the V-bolt **90** against the back of the L-bracket **93**. Thus the bi-directional switching amplifier module housing **94** is secured as designed with the connectors **20**, **29** facing downward. As seen in figure 7, the L-bracket **93** provides convenient mounting for the amplifier housing **94** to the V-

bolt **90** as well as providing additional weather protection as a roof-covering.

Description of Preferred the PC Board Mounting Arrangement

The Printed Circuit (PC) boards **61** containing the electronic circuitry for the bi-directional switching amplifier module **1** and DC power injector **2** are preferably mounted to the top cover or lid **62** of their respective enclosures. This permits the coax connectors **64** to be mounted directly to the PC board **61**, which provides for the best impedance match from these connectors to the PC board **61**, with the PC board **61** traces **63** acting as strip lines to the circuitry on the board.

Figures 6A and 6B show how the PC board **61** is preferably typically mounted to the top cover or lid **62** of the enclosure. The coax connectors **64**, for example N-female type, protrude through holes on the top of the cover **62**. The flange **64'** of connector **64** is sandwiched between the inside of the top cover **62** and the ground plane bottom of the PC board **61**. The flange **64'** of the connector **64** is fastened between

the top of the cover **62** and the bottom PC board **61** using appropriate machine screws **97** and nuts **98** or any other fastening scheme intended by the manufacturer of the connector **64**. The center pin **92** of the connector is soldered or otherwise electrically connected directly through to the PC board **61** to trace **63**, which forms a preferably 50-ohm stripline to the rest of the RF circuitry. The ground connection to the PC board is secured through four mounting screws **97** or other equivalent fastening means. This presents the lowest VSWR to the transmission line connected to the device on **61** through the connector **64** and provides for the least possible loss.

A highly efficient RF bi-directional switching amplifier, housing, universal mounting and electrostatic overvoltage protection means are disclosed for a modern telecommunications system. Thus by using the disclosure and teachings of the invention, any practitioner in the art is enabled to make and use the invention.

What we claim is:

1. In a telecommunications device having a signal input, an electrostatic overvoltage protection device, comprising:

a conductor connected between said signal input and a source of reference potential.

2. The electrostatic overvoltage protection device of Claim 1, wherein:

said conductor has a length selected to be one quarter of the wavelength of a desired signal band frequency, and

the source of reference potential is a ground potential.

3. The electrostatic overvoltage protection device of Claim 2, wherein:

the conductor of one quarter wavelength is one of a trace on a circuit board and a wire.

4. The electrostatic overvoltage protection device of Claim 2, further comprising:

a T-connector having an external housing and with a through conductor between the main end terminals, and a side conductor connected at one end to the to said through conductor and at the other end to the side end terminal of said T-connector, and

a shorting structure connecting said other end of said side conductor to said T-connector external housing, wherein

said conductor of one quarter wavelength is measured from said one end of said side conductor to said shorting structure.

5. The electrostatic overvoltage protection device of Claim 4, wherein:

said shorting structure further comprises a conductive cap with a conductive pin adapted to fit into said T-connector side end terminal and thus make electrical connection between the combination of said conductive pin and said side conductor and said T-connector external housing.

6. A telecommunications device having an antenna, comprising:

a bi-directional switched amplifier, said amplifier being switched between transmit (TX) and receive (RX) modes,

said bi-directional switched amplifier further being located physically adjacent to said antenna, such that signal losses between said bi-directional switched amplifier and said antenna are negligible.

7. A waterproof housing arrangement for an active electronic device having at least one external connection, comprising:

a housing containing said active electronic device which is waterproof on all sides except for the side containing said at least one external connection;

mounting said housing such that said side containing said at least one external connection is in a downward position.

8. A waterproof housing arrangement for an active electronic device as in Claim 7, further comprising a first conductor connected to said at least one external connection, said first conductor forming a U-loop beneath said housing.

9. A waterproof housing arrangement for an active electronic device as in Claim 8, further comprising:

a second external connection, said second external connection also being located on the downward side of said housing, and further being connected to a source of direct current power through a second conductor;

said first conductor leading away from said downward side of said housing and being connected to an antenna located adjacent said housing.

10. A waterproof housing arrangement for an active electronic device as in Claim 9, wherein:

said antenna is located adjacent to said housing such that losses between said active electronic device and said antenna are negligible.

11. A waterproof housing arrangement for an active electronic device as in Claim 7, wherein:

said housing is mounted to a pole.

12. A waterproof housing arrangement for an active electronic device as in Claim 11, wherein:

said pole is in a vertical direction.

13. A waterproof housing arrangement for an active electronic device as in Claim 12, wherein:

said housing is attached to said pole by a V-bolt fastener.

14. A waterproof housing arrangement for an active electronic device as in Claim 12, wherein:

said housing is attached to said pole through an L-shaped bracket, said L-shaped bracket being attached to the top of said housing, and

a V-bolt fastener connecting said L-bracket to said pole.

15 The waterproof housing arrangement for an active electronic device as in Claim 14 wherein:

said L-shaped bracket further being of sufficiently large size so as to overhang at least three vertical sides of said housing, to thus provide additional waterproofing to said housing.

16. The waterproof housing arrangement for an active electronic device as in Claim 7, wherein:

said active electronic device is a bi-directional switched amplifier.

17. A mounting arrangement for an external connection to an electrical circuit, comprising:

a housing,

a connector for said external connection, said connector protruding through a wall of said housing,

said connector having a flange, one side of said flange directly abutting the inside wall of said housing,

said electrical circuit being mounted on a substantially planar board having two sides, and

the other side of said flange of said connector abutting and being directly connected to one side of said planar board.

18. The mounting arrangement for an external connection to an electrical circuit as in Claim 17, wherein:

said connector is a coaxial connector, and

the center contact of said coaxial connector protrudes through and is connected to the second side of said planar board, to provide for minimum VSWR from said coaxial connector to said planar board.

19. The mounting arrangement for an external connection to an electrical circuit as in Claim 18, wherein:

said housing has a cover, and

said coaxial connector protrudes through an aperature in said cover.

20. A bi-directional switched RF amplifier, comprising:

an external connection to an antenna,

an external connection to a transceiver radio,

a transmitting (TX) amplifier,

a receiving (RX) amplifier,

said transmitting and said receiving amplifiers being arranged between said radio and antenna external connections,

a double pole, double throw switch, one switch pole connected to said radio external connection and the other switch pole being connected to said antenna external connection,

such that when said double pole, double throw switch is in one position the transmitting amplifier is disconnected from said external connections, and the input of said receiving amplifier is connected to said

antenna external connection and the output of said receiving amplifier is connected to said radio external connection,

such that when said double pole, double throw switch is in the other position the receiving amplifier is disconnected from said external connections, and the input of said transmitting amplifier is connected to said radio external connection and the output of said transmitting amplifier is connected at said antenna external connection, and

said position of said double pole, double throw switch being controlled by a transmit power sense circuit.

21. A bi-directional switched RF amplifier as in claim 20, wherein: said receiving amplifier is a low noise amplifier.

22. A bi-directional switched RF amplifier as in Claim 21, additionally comprising:

a bandpass filter connected between said antenna external connection and said receiving amplifier input, and

pads, including attenuation pads, connected to at least one of said receiving amplifier output and said transmitting amplifier input.

23. A bi-directional switched RF amplifier as in Claim 20, wherein:

the powering for both said receiving amplifier and said transmitting amplifier is a source of DC potential applied through said external connection to a radio transceiver through a DC power injector.

24. A direct current (DC) power injector circuit for a remote bi-directional switched RF amplifier, comprising:

a source of direct current connected to said remote bi-directional switched RF amplifier through a current sensor.

25. A direct current (DC) power injector circuit for a remote bi-directional switched RF amplifier as in Claim 24, further comprising:

a connection from said current sensor through a capacitor to a radio transceiver.

26. A direct current (DC) power injector circuit for a remote bi-directional switched RF amplifier as in Claim 25, wherein:

said current sensor comprises a power resistor with two terminals in series between said source of direct current and said remote bi-directional switched RF amplifier,

and,

a differential voltage comparator is connected across said power resistor terminals to determine the operational mode of said remote bi-directional switched RF amplifier.

27. A direct current (DC) power injector circuit for a remote bi-directional switched RF amplifier as in Claim 26, further comprising:

a pair of indicator lights, only one of which will be on at any time, to thus indicate said operational mode, either receive RX or transmit TX, of said remote bi-directional switched RF amplifier.

28. Temperature compensated RF sensing circuitry, comprising:

a first voltage reference connected between a power supply voltage and a reference potential,

a thermistor being connected to said first voltage reference to provide temperature compensation therefor,

the output of said first voltage reference connected to one end of a pair of series connected diodes, said output of said first voltage reference forward biasing said pair of series connected diodes in the forward direction to just below the point of conduction,

the common connection between said pair of serially connected diodes being coupled to an external source of radio frequency (RF) signal,

the other end of said pair of serially connected diodes being connected to a comparator circuit, wherein:

when the amplitude of the source of radio frequency signal is zero or below a predetermined threshold, this generates one state output of the comparator circuit, and

when the amplitude of the source of radio frequency signal is at or above said predetermined threshold, this generates a second state output of the comparator circuit.

29. A temperature compensated RF detection circuit as in Claim 28, wherein:

said source of radio frequency signal is a transceiver, remote from said temperature compensated RF detection circuit, and

said comparator circuit output states control a bi-directional switching radio frequency amplifier to control said amplifier into either a receive or a transmit condition.

30. A temperature compensated RF detection circuit as in Claim 29, wherein:

a second voltage reference with an output is connected between a power supply voltage and a reference potential,

said comparator circuit comprises a pair of differential comparators, each with two inputs and an output respectively,

one input of each of said pair of differential comparators is connected to said output of said second voltage reference,

the other input of one of said pair of differential comparators is connected to said other end of said pair of serially connected diodes, and

the other input of the other of said pair of differential comparators is connected to the output of said one of said pair of differential comparators,

whereby only one of said pair of differential comparators has a High output at any time, thereby indicating said amplitude of said source of radio frequency signal.

31. A temperature compensated RF detection circuit as in Claim 30, wherein:

said first and second voltage references comprise a plurality of serially resistors between said power supply voltage and said reference potential.

32. A telecommunications system, comprising:

a remote bi-directional switched radio frequency (RF) amplifier in a waterproofed housing with an adjacently mounted antenna and a first connection to said antenna located on the lower side of said waterproofed housing,

a single radio frequency and direct current power line connected between a second connection to said lower side of said waterproofed housing and a direct current power injector removed from said antenna,

a radio transceiver connected to said direct current power injector, and,

a terminal device connected to said radio transceiver to communicate data through said system.

33. A method of sensing the discrete operational states of a device remote from a direct current power supply powering said device, said discrete operational states each using different levels of electrical power, comprising:

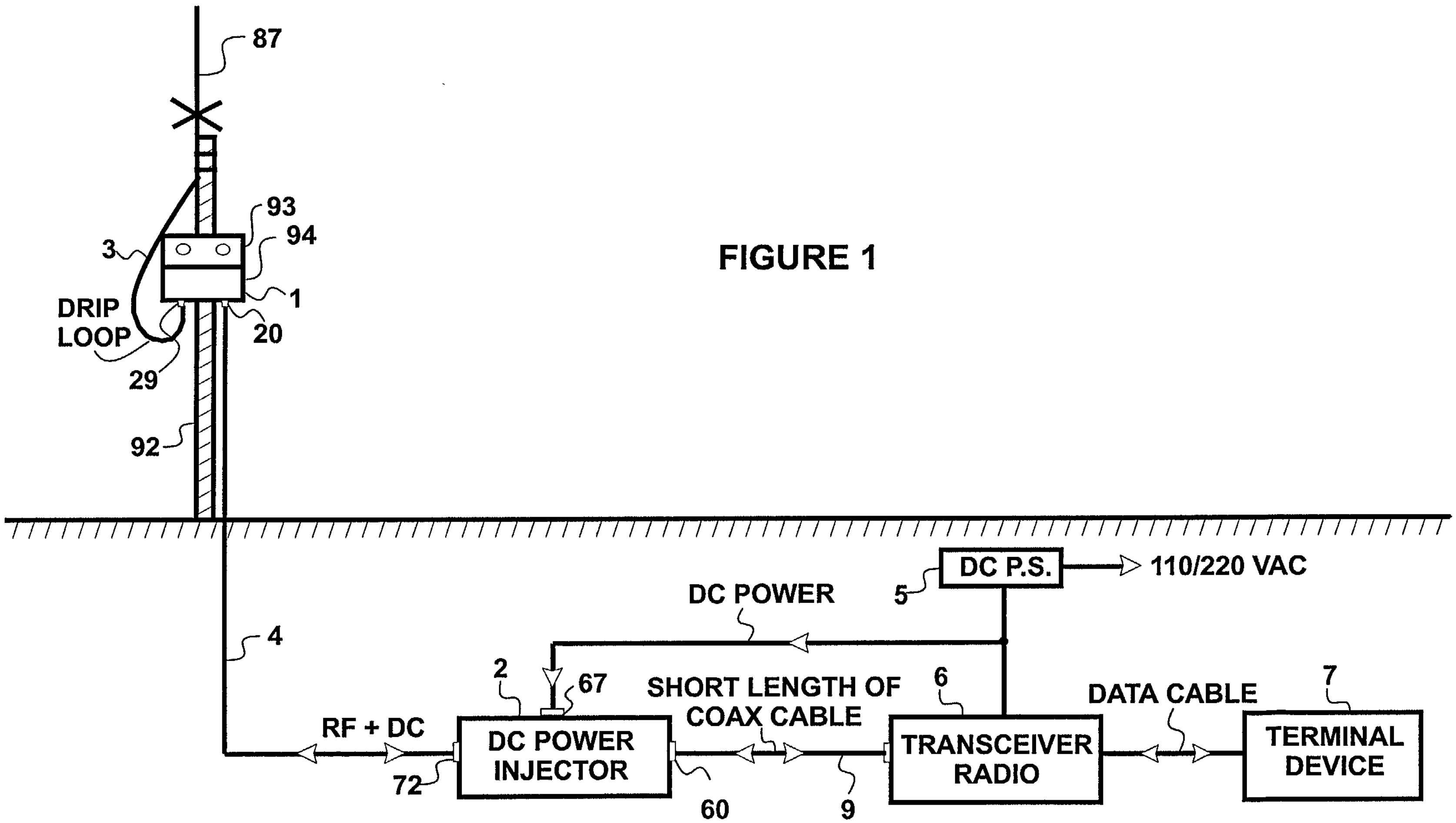
putting the current being drawn by said device through a series connected resistor,

sensing the voltage drop across said resistor by a differential voltage comparator, and

optically outputting the results of said comparator, said output indicating one of said discrete operational states of said device.

Abstract of the Disclosure

A remotely mountable weatherproof bi-directional, half-duplex switching amplifier system is designed to provide maximum range for low power half-duplex radios such as Spread Spectrum radio transceivers. This invention automatically senses when to go into the transmitter amplification mode and puts all the transmit power right at the antenna. In the receive mode, it provides low noise pre amplification of received signals at the antenna thereby minimizing or even eliminating the effects of the coaxial transmission line from the radio transceiver to the remote location of the antenna. The invention is preferred to be in a waterproof enclosure adjacent to the antenna mounted to a pole and powered by a DC injector and excited by a transceiver, both pole and injector located remote from the mounting pole and also includes an improved electrostatic overvoltage protection device.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93
94
3
1
DRIP
LOOP
20
29
92
4
DC P.S.
110/220 VAC
5
DC POWER
2
67
SHORT LENGTH OF
COAX CABLE
6
7
DATA CABLE
RF + DC
DC POWER
INJECTOR
TRANSCEIVER
RADIO
TERMINAL
DEVICE
72
60
9

FIGURE 1

FIGURE 2

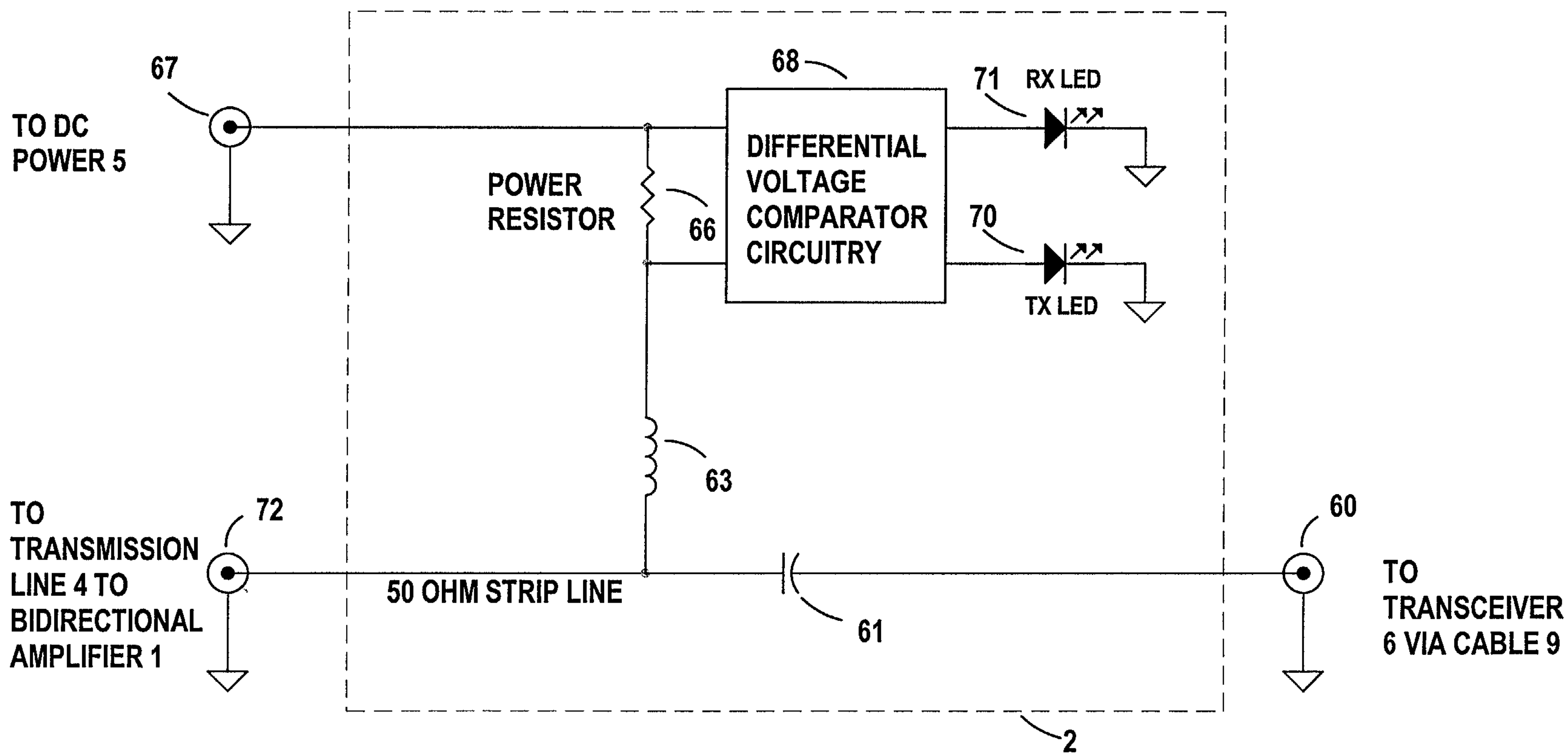
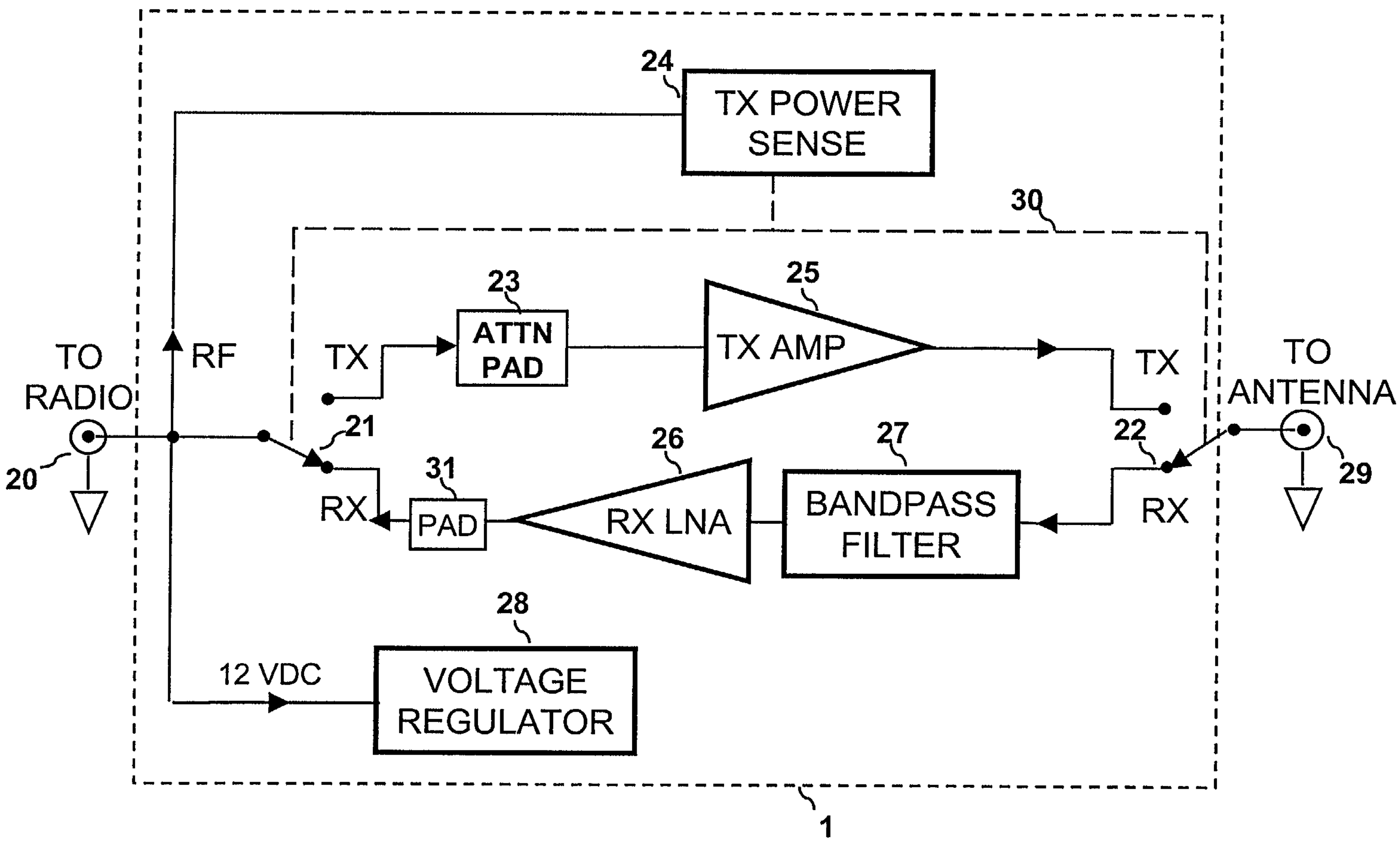

TO DC
POWER 5
67
POWER
RESISTOR
66
68
DIFFERENTIAL
VOLTAGE
COMPARATOR
CIRCUITRY
71
RX LED
70
TX LED
63
TO
TRANSMISSION
LINE 4 TO
BIDIRECTIONAL
AMPLIFIER 1
72
50 OHM STRIP LINE
61
60
TO
TRANSCEIVER
6 VIA CABLE 9
2

FIGURE 3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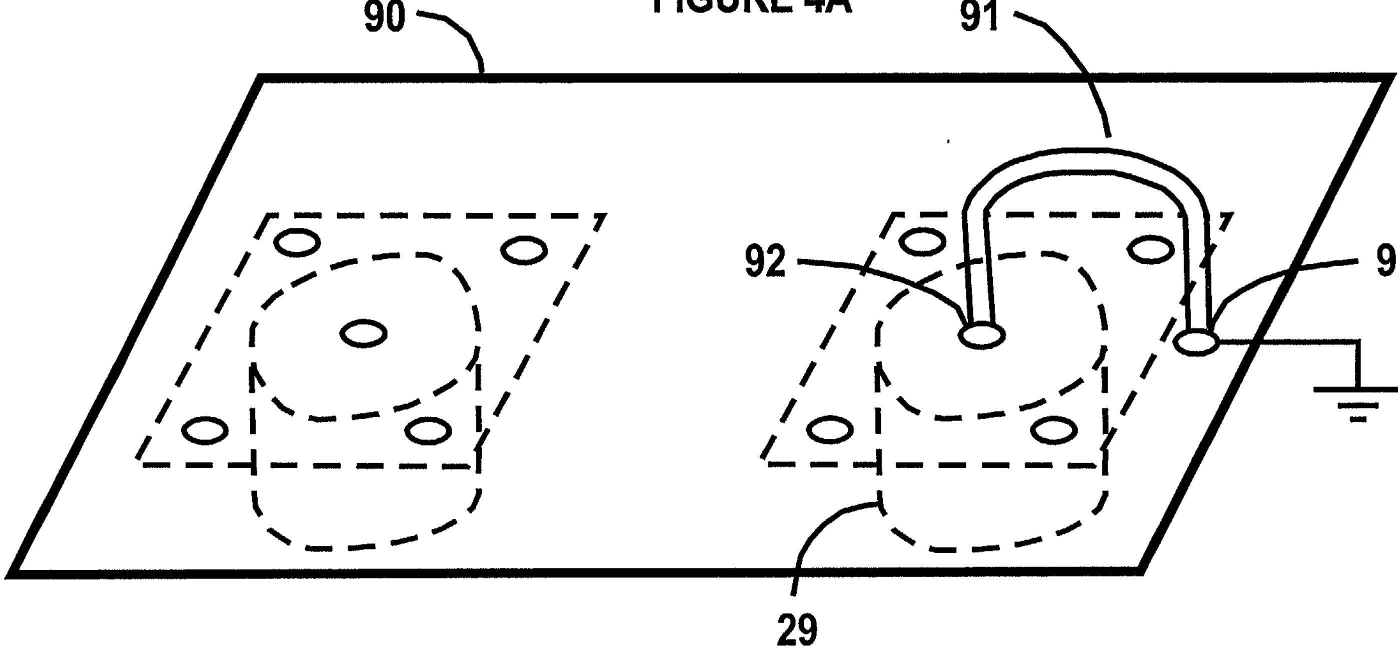
24
30
23
ATTN PAD
25
TX AMP
TX
TX
RF
TO RADIO
TO ANTENNA
20
21
RX
31
PAD
26
RX LNA
27
BANDPASS FILTER
22
RX
29
28
12 VDC
VOLTAGE REGULATOR
1

FIGURE 4A



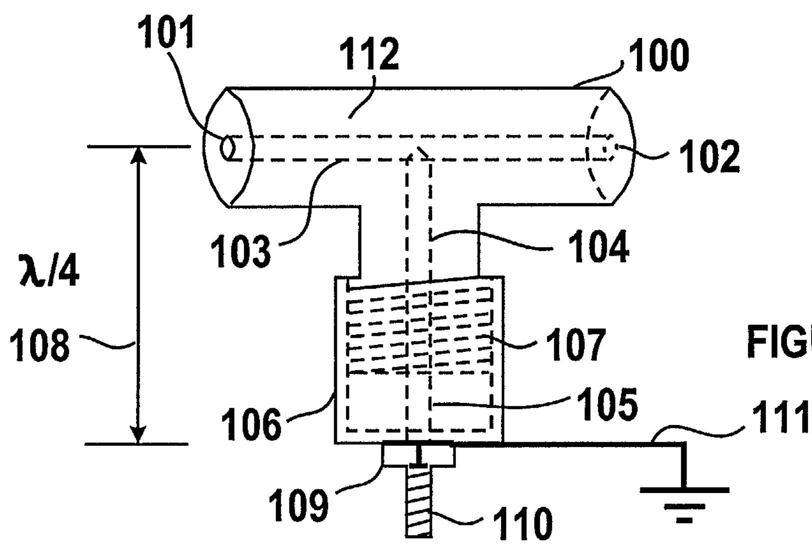


FIGURE 4B

FIGURE 5

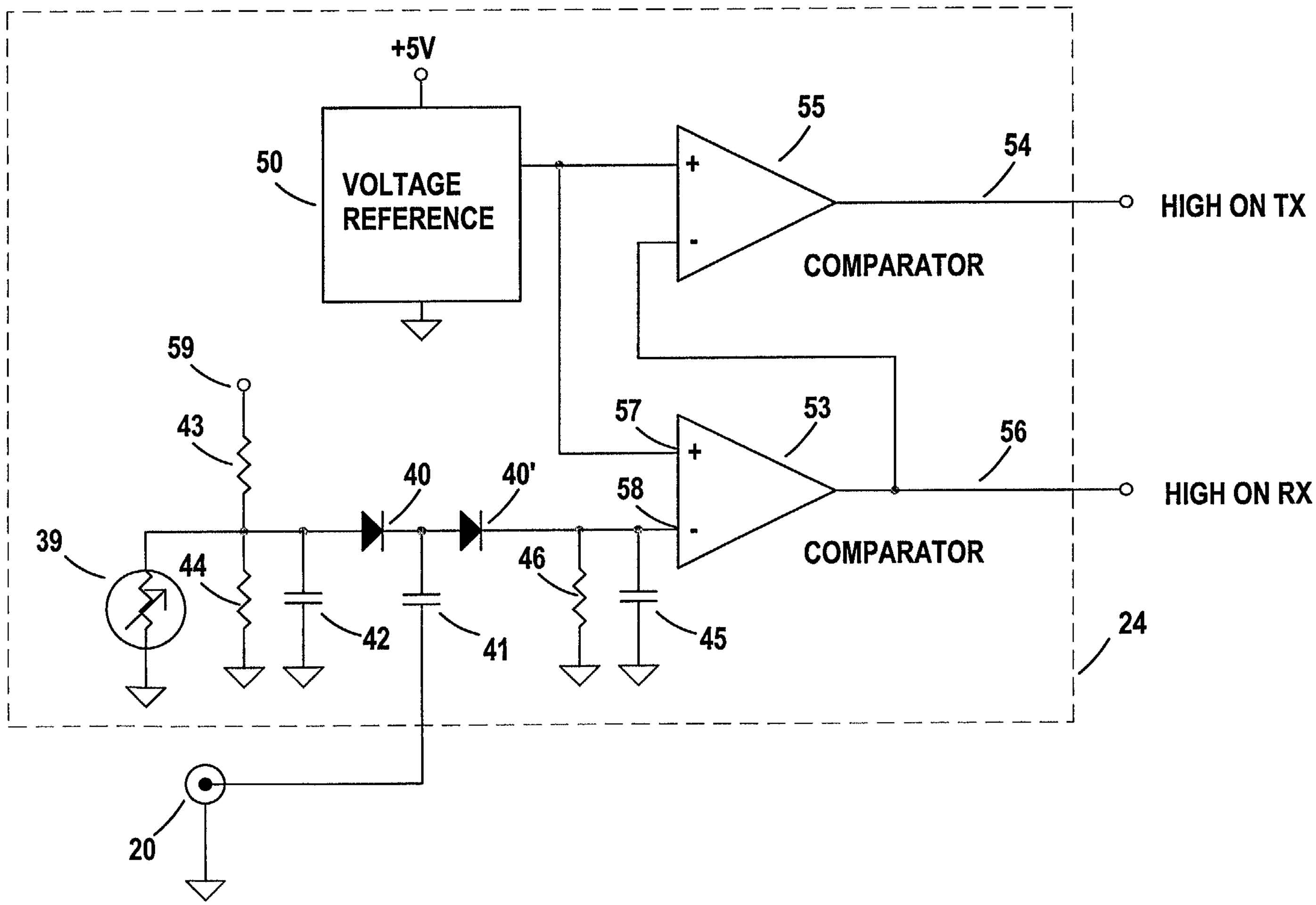
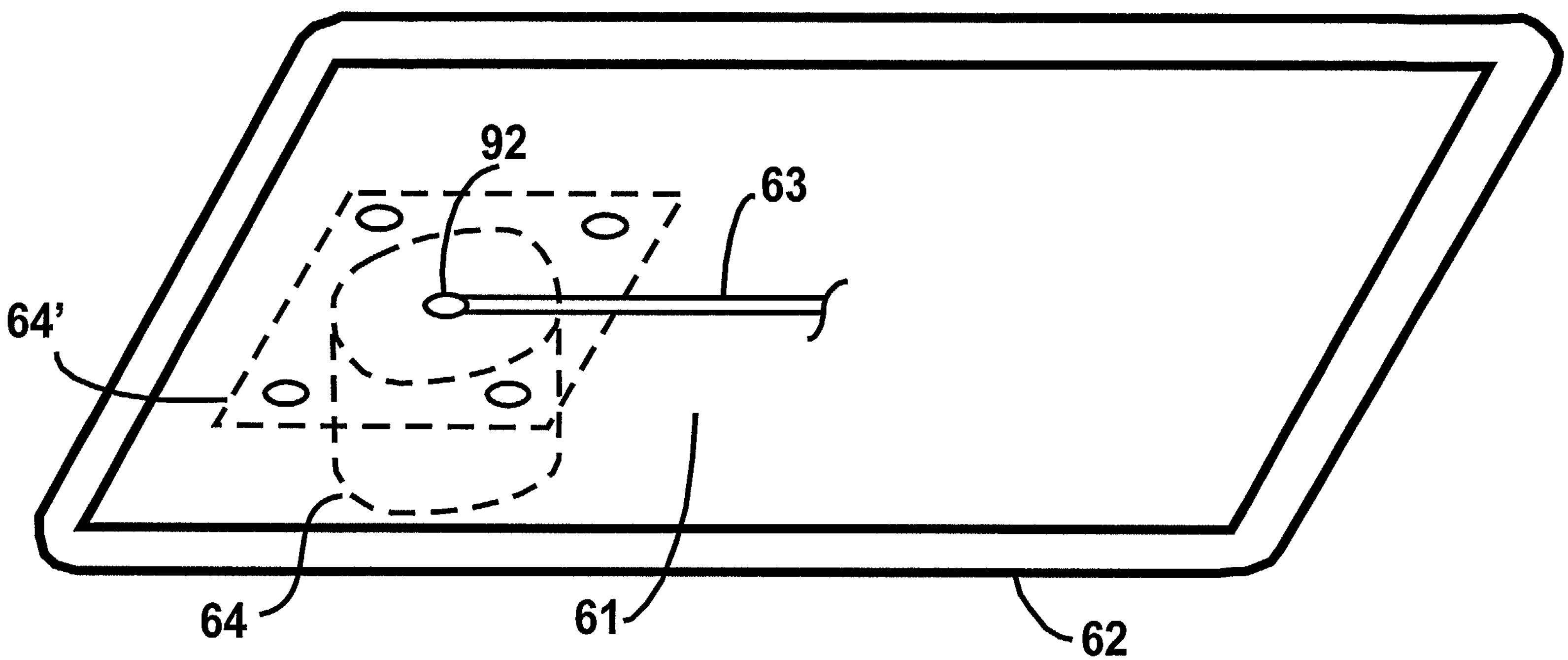

+5V
50
VOLTAGE
REFERENCE
55
54
HIGH ON TX
COMPARATOR
59
43
57
53
56
HIGH ON RX
40
40'
58
39
44
46
COMPARATOR
42
41
45
24
20

FIGURE 6A



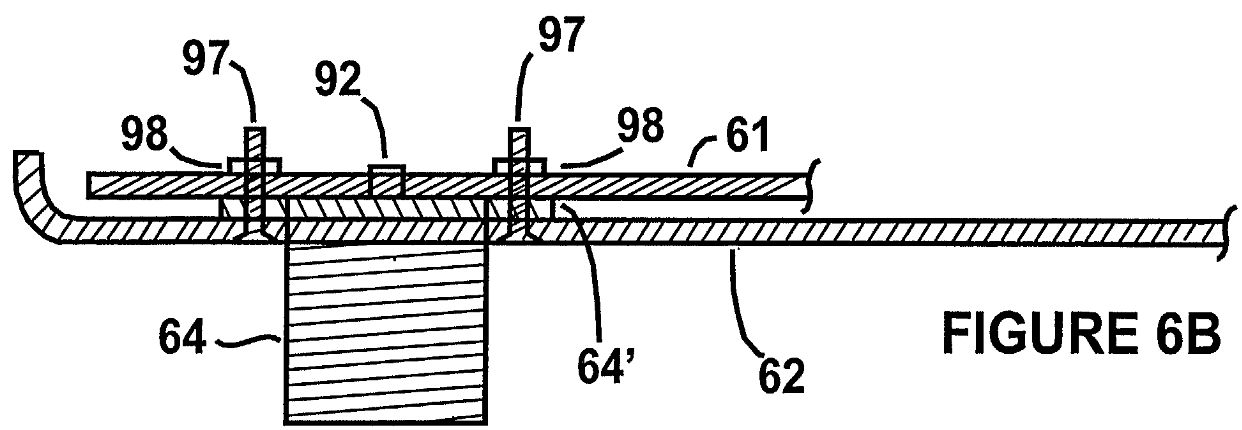


FIGURE 6B

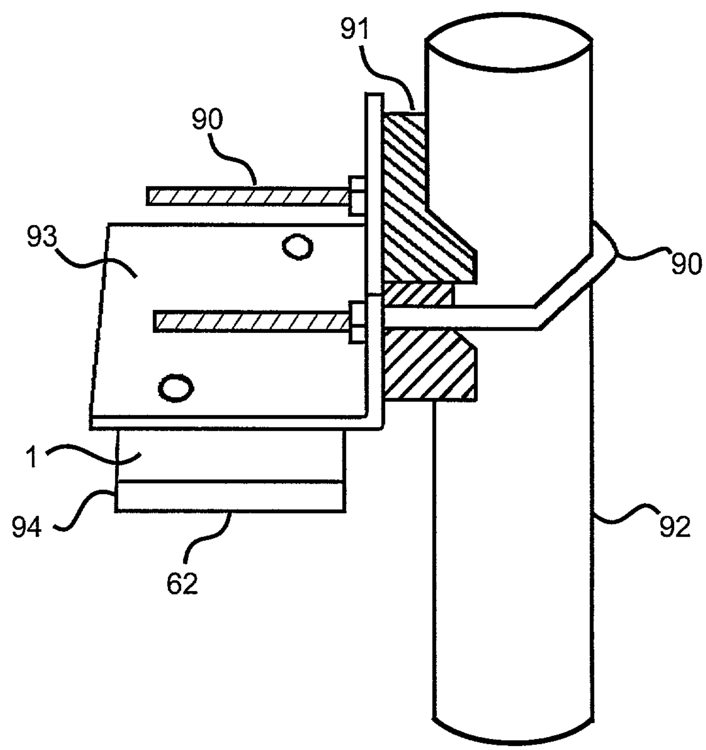


FIGURE 7

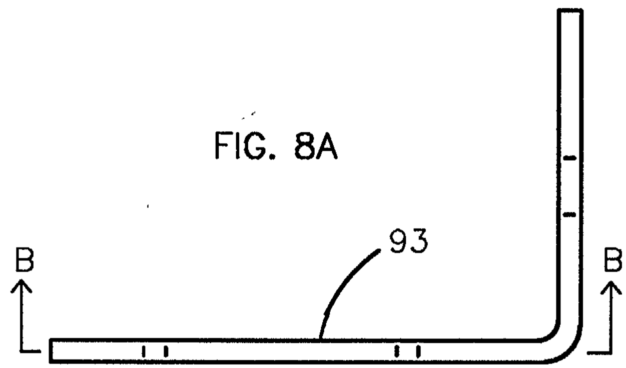


FIG. 8A

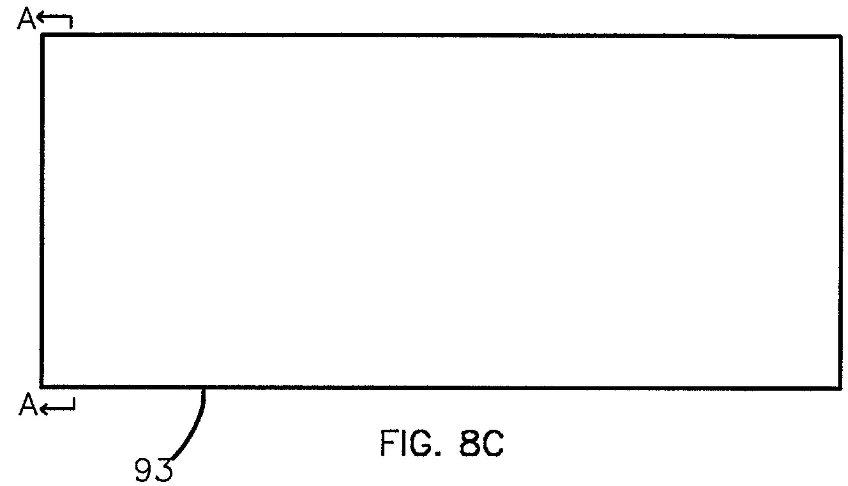


FIG. 8C

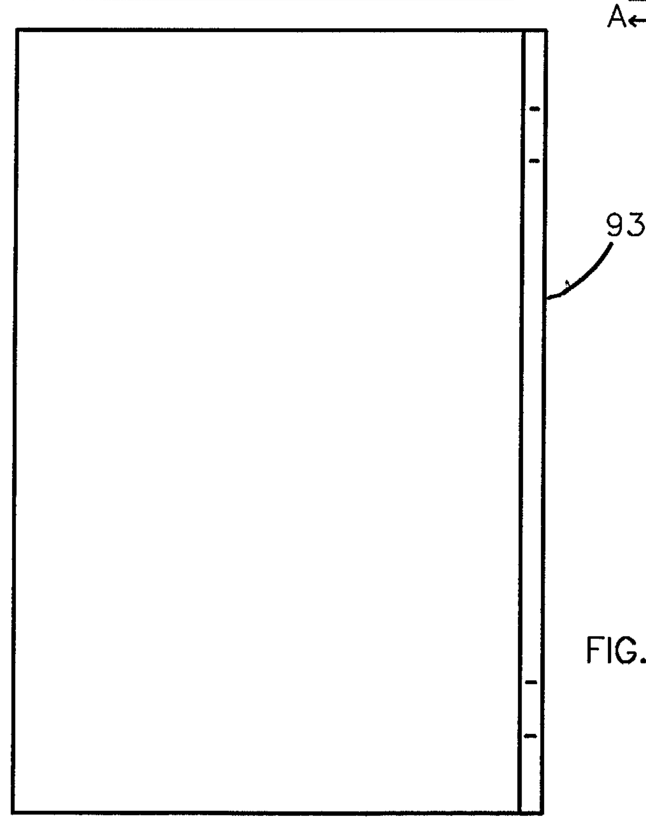


FIG. 8B

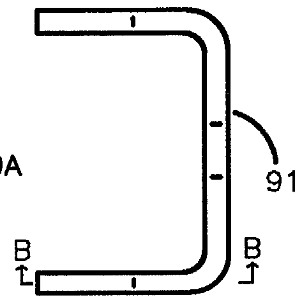


FIG. 9A

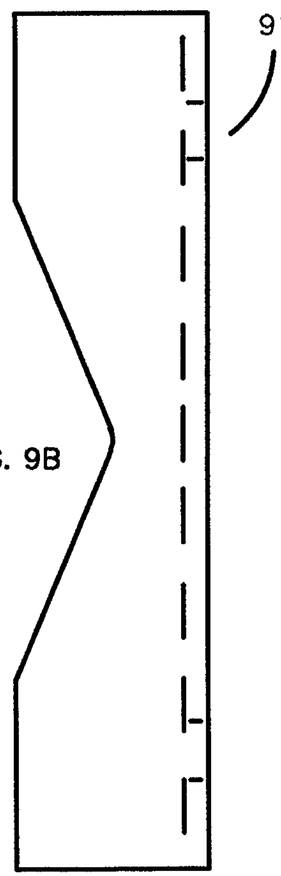


FIG. 9B

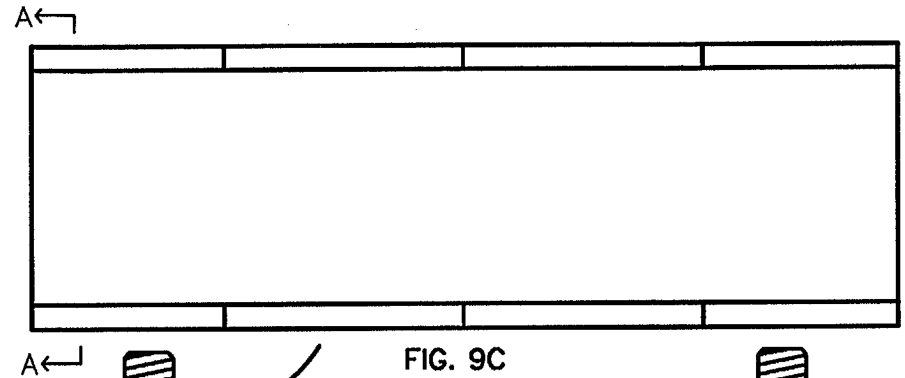


FIG. 9C

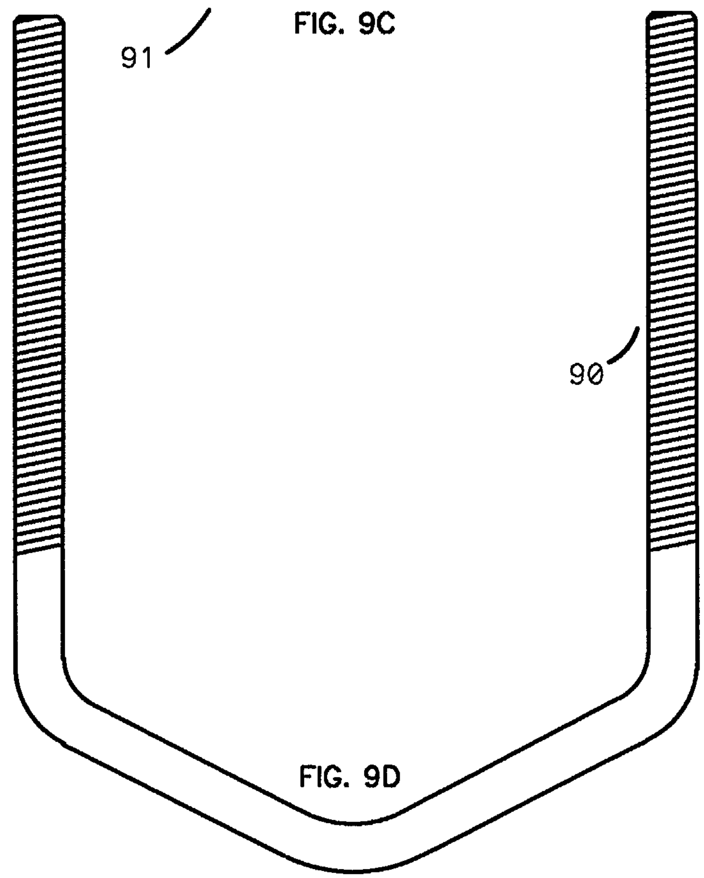


FIG. 9D

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	
First Named Inventor	MICHAEL F. YOUNG
COMPLETE IF KNOWN	
Application Number	60 / 120, 639
Filing Date	02/18/99
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

BI-DIRECTIONAL SWITCHED RF AMPLIFIER, WATER PROOF HOUSING, ELECTROSTATIC OVER VOLTAGE PROTECTION AND MOUNTING BRACKET THEREFOR

(Title of the Invention)

the specification of which

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
60/120, 639	02/18/1999	☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

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Approved for use through 9/30/00. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
OR
☐ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☒ Correspondence address below

Name	MICHAEL F. YOUNG				
Address	7110 SEA CLIFF RD				
Address					
City	Mc LEAN	State	VA	ZIP	22101
Country	USA	Telephone	703-790-8989	Fax	703-237-9090

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
MICHAEL F.	YOUNG

Inventor's Signature	MFY					Date	2/14/00
Residence: City	Mc LEAN	State	VA	Country	USA	Citizenship	USA
Post Office Address	7110 SEA CLIFF ROAD						
Post Office Address							
City	McLEAN	State	VA	ZIP	22101	Country	USA

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page 2 of 3

Name of Additional Joint Inventor, if any: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
HUNTER	JONES

Inventor's Signature	[signature]					Date	02/14/2000
Residence: City		State		Country		Citizenship	USA
Post Office Address	717 TANLEY RD						
Post Office Address							
City	SILVER SPRING	State	MD	ZIP	20904	Country	USA

Name of Additional Joint Inventor, if any: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
JOHN	CASAER

Inventor's Signature	John Casaer					Date	2/14/2000
Residence: City	McLEAN	State	VA	Country	USA	Citizenship	USA
Post Office Address	1532 LINCOLN WAY						
Post Office Address	APT 103						
City	McLEAN	State	VA	ZIP	22102	Country	USA

Name of Additional Joint Inventor, if any: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
PAUL	AKIMOV

Inventor's Signature	Paul Akimov					Date	2/14/2000
Residence: City	SPRINGFIELD	State	VA	Country	USA	Citizenship	USA
Post Office Address	6418 CHARNWOOD STREET						
Post Office Address							
City	SPRINGFIELD	State	VA	ZIP	22152	Country	USA